end of September. Fire-suppression costs and losses of a majority of all the other protective organizations west of the Cascades also took a decided upward trend in the first two decades of September, and on into the month of October for a few of these organizations. And it was necessary for some of the protective organizations to maintain patrol forces in the field until the first week in December, the first time in the history of organized protection.

The largest fire in Oregon occurred in eastern Marion County, and burned over approximately 46,000 acres with an estimated loss of $400,000, the greatest loss being in logs and logging equipment. There was also a big loss in reproduction. This fire started on September 6, and made its biggest run on the 6th, 7th, and 8th, but continued very troublesome until the 17th. Old experienced fire fighters on this fire stated burning conditions were the nearest thing to spontaneous combustion they had ever witnessed. Another large fire was one of about 20,000 acres in west Lane County, and another of about 18,000 acres in southern Clackamas County. There were also a number of other fires of from 2,000 to 5,000 acres. The site of the Yacolt Burn of 1902 in Washington was again largely swept by fire, the total acreage burned over amounting to approximately 150,000 acres. This fire was started early in August by a smoker, but made its biggest run in the first part of September.

Dense smoke prevailed west of the Cascades from the 6th to the 19th of September, being quite dense during the latter part of this period, and over eastern Oregon from September 12 to 19, being densest from the 16th to the 19th. Smoke was so dense in the Columbia River Gorge and vicinity from the 16th to the 18th that it was pitch dark most of the time and it was necessary to carry lanterns in the daytime in order to see to get around. Wind River Forest Experiment Station in Washington, in the Cascades north of the Columbia River Gorge, reported that the smoke cloud overhead on September 17, the bottom of which was about 500 feet above the ground, was so dense that it was actually pitch dark at the station in the middle of the day. The Weather Bureau cooperative observer at French Glen, in southeastern Oregon near the Idaho-Oregon boundary line, reported that the smoke was so dense on September 18 and 19 that visibility was not over 500 yards. The dense smoke made lookouts for sighting and reporting fires practically worthless, and observation by airplane very poor, and it became necessary for the protective organizations to put on extra guards for fire-patrol duty.

Special fire-weather warnings were telegraphed daily to the protective organizations of western Oregon from September 1 to 19, and again for several days at the end of the month. Many long-distance telephone calls were also received from those forestry interests desiring special information relative to fire-weather conditions.

There were recurrent periods of bad fire weather in October, November, and the first week in December, when burning conditions were good and gave the protective organizations and logging operators much concern.

Protective organizations in the Siskiyous and southern Coast Range sustained their heaviest fire losses of the season during the latter part of November and the first week in December. It was the first time in history that destructive fires have occurred so late in the season. The largest of these fires was the Barklow Mountain fire, which started the day before Thanksgiving and burned over more than 10,000 acres. Thanskgiving Day and night and the following day were bad fire-weather days, and were the days on which this fire and other fires made their biggest runs. Protection men reported that stiff east and northeast winds came in in a whirl, and that cold nights with dense fog prevailed in the lower valleys and levels while warm clear weather with relatively high temperatures and low relative humidities prevailed at the higher elevations. The barometric pressure was extraordinarily high at this time over the Plateau Region and western Canada.

The fire-weather season of 1929, within the history of Weather Bureau records, was undoubtedly the worst that has ever occurred in the Pacific Northwest, at least since 1868 when heavy fire losses occurred. According to the precipitation records at Astoria, Oreg., August and September of 1868 were very dry months, and it is well known that extremely heavy fire losses occurred in September, so extremely bad fire-weather conditions must have prevailed at that time. Fire-weather conditions for September of 1902 were bad and severe fire losses were sustained, but available weather records, while indicating serious fire-weather conditions for the most of one week, nevertheless, do not indicate that these conditions were as bad as for September for 1929. The extremely hazardous fire-weather conditions which prevailed during the latter part of the season for 1929 will long be remembered by the forest-fire protective organizations of Oregon and of all the Pacific Northwest as well.

FIRE WEATHER AND FIRE CLIMATE

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Climatological data, for all portions of the earth's surface for which records of the weather elements are made, have become well standardized. Comparisons of the principal elements of the climate—temperatures, their means and extremes, and precipitation, its character, seasonal distribution and variability—are readily possible. Such comparisons are only possible, however, from the fact that there is uniformity of treatment of data, nationally and internationally, and the need for such uniformity is obvious. There is now a newly born, but rapidly developing, branch of meteorology and climatology for which no such uniformity of method of compilation of essential facts has been developed. Reference is made to the now rather widely spread studies of those phenomena known as "fire weather." While fire-weather data are being accumulated in increasingly large amounts, especially in parts of North America, there has as yet been no standardization of the ultimate treatment of such facts, so that a "fire climatology" may be established which will allow of comparison of the basic elements of the natural fire hazard over different regions as readily as a comparison of the general climate may be made at present. That there should be some such standardization would seem obvious enough. It is desired to set forth in the following paragraphs a tentative scheme, or suggestions, for a comprehensive fire climatology, which may form a basis for discussion, at least, and may ultimately, even if largely modified in accordance with the views of others, lead to the adoption of standard methods in the several districts in which fire-weather studies are being made.

As a preliminary to the statement of manner of compilation of data some short discussion of the elements of fire weather, and the manner of securing fire-weather data should be pertinent. The weather elements generally accepted as affecting the degree of the fire hazard on forested, reforesting, cut-over and water-shed lands, with which we are chiefly concerned, are:

1. Precipitation, its amount, distribution, and variability.
2. Relative humidity, normals and extremes, with the frequency and persistence of critical percentages.
3. Winds, their direction and velocities.
4. Lightning (an important and the only weather agency causative of fires), its geographical distribution and frequency, with attention also to attendant precipitation.

These four are the really important elements. Temperatures are important mainly as affecting the percentage of relative humidity. High temperatures may be attended by high relative humidity, normal or subnormal temperatures are not infrequent with abnormally low percentages of relative humidity and an acute fire hazard. Absolute humidities are normally much higher in summer, the normal fire season, than in winter. For example, at Seattle the mean vapor pressure for January (at 5 p. m., local standard time) is 0. 219 inch, in August it is 0. 399 inch. The average temperature of the dew point at the same hour, varies from 36.2° in January to 52.6° in August. It is true that absolute humidity and temperature, considered in their relation to each other, do indicate the degree of the fire hazard, but this relationship resolves itself into the relative humidity, the direct index of the desiccating effects, or otherwise, of the atmosphere.

In certain districts investigators have stressed the importance of "duff humidity" as an index of the fire hazard, or rather as an index of the inflammability of the fire material. This is ascertained by periodic weighing of a fixed sample of the duff in situ, by measurements of the varying electrical resistance in certain plots, or by means of the "duff hygrometer," which latter shows, in effect, the relative humidity of the air in immediate contact with the duff particles. Without minimizing the importance of this method of measurement of the hazard it must be said that the condition of the duff is the resultant of antecedent and current weather conditions, particularly of precipitation and relative humidity, but itself is not a weather element. Accurate results from either of the three methods seem to require considerable preparation of sites and of frequent calibration of instruments. Hence, while of some importance as affording a "check" on the existing fire hazard it does not seem that such data need be included in any consideration of fire weather or fire climate except as supplemental material.

The four weather elements noted above being accepted as those directly affecting the fire hazard it is readily seen that the fire climatology of any region must be a summation of all manner of data concerning them.

It must also be premised that the general climatic characteristics of a region determine the nature of the forests and ground cover; that fire weather is an abnormal condition causing a fire hazard in excess of that normal for the season and region, so that the indices of increased hazard should be based on the departures of the several elements from their norms for each season and for the region considered. This being the case the fire climate will be determined by a record of the frequency and the degree of the abnormalities of the several elements, as well as by a record of their norms or means. And this will require a more extensive and intensive study than would be required to determine the general climate of a region.

Precipitation.—A complete record of the precipitation is essential. Normals should be established. The number of reporting stations will be determined by the general topographic and climatic characteristics of the region. For example, the States along the Pacific coast each have a zone of maritime and one of continental climate. Within each zone the local controls of precipitation are largely orographic. Annual totals vary from the order of 130 inches or more to that of 5 inches or less. There are important differences to windward and leeward of mountain ranges. Valleys of different axes have varying totals, within short distances. For such regions, that there may be an adequate survey, a seemingly excessive number of stations may be needed. For other regions, of more homogeneous terrain, only a fraction of the number may be ample.

Having adequate reports, what data shall be compiled? First, naturally, the normals. Monthly means are of value, but those for a shorter period will be of far greater utility. The decade, or rather the periods ending on the 10th, 20th, and last days of the month seem to be the most practicable subdivision, at least until such time as the uniform 4-week month shall have been adopted. This applies as well to computations of averages or means for all the other fire weather elements.

The character of the precipitation during the seasons is important. Does it occur in occasional heavy showers, with long dry intervals, or in more frequent light rains? How frequently can rains sufficient to moisten the forest floor and make for a period of safety be expected? To know this we should record the number of days with occurrences of each class of precipitation, from the least measurable through certain graduations up to 1 inch or more. The actual amounts may be made a matter of agreement, to the writer it would seem that records of the frequency of 0.01, 0.04, 0.10, 0.25, and 0.50 inch should be ample, or possibly more than ample, considering the clerical work required for the compilations.

Rainless periods, their duration and frequency, are of the utmost importance. It may be stated that prolonged rainless periods over sections which normally enjoy copious rains upset the normal equilibrium to a greater extent and cause a more acute fire hazard (given critical humidities) than do such periods of similar length over regions of scanty rainfall. The occurrence of dry periods of 4, 6, 8, 10, 15, 20, 30, and 40 days, with extremes, should be recorded, by the number of such periods beginning in each decade, or, possibly, for convenience, in each month. For an evaluation of the possible fire hazard over any area such data are of the greatest importance, but they can not be obtained from a scanning of decade or monthly averages of precipitation, in which the occurrence of the occasional drought is well hidden. Long dry periods have been found to be not infrequent even in the portion of western Washington which has local annual precipiation ranging from 80 to 140 inches.

It has been, by some, customary to object to the use of the hygrograph, on the ground that it is not an instrument of precision. Granted that there may be a slight inaccuracy, observation and study of the records for such instruments, frequent checks of many instruments, and a comparison with records from psychrometer observations, has convinced the writer that the probable error in the record from a well-calibrated instrument of the later models, as in the hygrothermograph of 1927, is no greater, if as great, as the probable error of a psychrometer observation, even made by a normally competent observer, especially where dry and wet bulb temperatures are reported to whole degrees. The sources of probable and possible errors in psychrometer readings are many and various, and are mostly due to the proneness of human kind to become a bit careless, besides, there is a frequent lack of continuity. On the other hand, the automatic instrument, once properly calibrated, and especially under normal woods exposure, will continue to make a good record indefinitely, with attention only once a week. Should a mechanical defect develop the fact is readily apparent, and corrections are usually simple. The continuity of the record is its great asset.

As competent observers can, and do, make acceptable records using the psychrometer, and as their cost is so much less than that of the hygrographs, they should be used at stations where but short-term records can be expected, furnishing valuable supplementary material by which the humidity survey may be considerably enlarged.

From the automatic records the following data can be segregated and compiled: The daily minima, with decade means; the number of hours of duration of the various critical percentages, with decade totals; the time of beginning of such critical periods, which can be averaged for the different parts of the season for the guidance of operators; the number of occurrences of critical periods, with decade averages; and the tendency toward persistence of such conditions for groups of two or more days; and a record of the frequency of nocturnal abnormalities (that is, critical conditions during the hours of normally high humidity). Some of these data may be extracted from the psychrometer records, but the actual minima, the duration, the hours of beginning, and the nocturnal abnormalities will not appear therein. From such records the decade averages for each of the three observations should be set down, in place of the average minima, that is, if the reports are of such continuity as to allow of valid averages.

Such a statistical analysis of the humidity element would afford just about all the information needed concerning this phase of the fire climate, but, for a large district having many stations, will require a great deal more clerical assistance than is now available. As to the "critical periods" to be recorded, the percentages of relative humidity, 40, 35, 30, 20, or any other, that are to be taken as indices of increased hazard, will depend altogether on local conditions and will require local determination based on a study of local problems. This determination should be a function of the forest protective agencies, or at least based on fire and weather history of the region and its subdivisions.

Winds.—Satisfactory records of wind directions and velocities are probably the most difficult of all to obtain, this despite the fact that accurate anemometers and elaborate recording instruments are available. The causes are two, lack of representative sites for exposure and the excessive cost of a complete instrumental installation. In a mountainous section it is difficult to find a site where recorded directions or velocities would be representative of any large area, or, given a fair site, to find an observer at that point. The effect of hills, mountains, and valleys on the local direction, and the local acceleration of wind movement due to the funnel effect of certain valleys, or to the convergence of two or more valleys, the local whirls, and other peculiarities, are too well known to be minutely described here. Lookout stations may give gradient directions, but the velocities are usually higher than over the wooded areas. And where funds are limited it is difficult to spare the large amount required for a complete installation of anemometer, supports, vane, and recording instruments. There should be, however, anemometers at least in representative geographical distribution, and as many other accessories as funds will allow. For record purposes the daily maxima, with duration, the prevailing directions, and the 4-hour average movement, with means, are probably the most important. Parenthetically, the hygrograph is a good auxiliary for determining basic wind direction; from its trace one can determine whether the local currents, from whatever direction reported, have their origin from the moist, or coastal direction, or from the dry interior.

Lightning.—For lightning reports we must depend altogether, as yet, on observations by eye and ear. Completeness of record is dependent on an adequate distribution of reporters and on their diligence in noting each manifestation within their districts. Storms may be classified as severe, moderate, or light, dependent on the number of flashes or peals observed or heard, with accompanying notes as to the amount of the accompanying precipitation. For record purposes a number of representative stations should be selected, the number again varying with the nature of the territory, and for each, the number of storms, in the several classifications, set down, by totals for each decade. Supplemental data, from protective organizations, as to the number and location of lightning fires, will form a most valuable adjunct to this record, in fact, will be indispensable if a correct estimate of the importance of lightning as a causative agent is to be formed.

For record of the geographical distribution and rate of progress of each storm base maps of the area, on which the location and hour of each report may be plotted, one for each date with storms, should be used. These give a graphic record of results which may be readily compared with the graphic presentation of the causative pressure and temperature distribution shown on the preceding and current synoptic charts, besides affording a permanent record.

It is realized that to set down so much of detail regarding each of many stations will require much time and labor and will result in a large volume of data. But no accurate determination of the fire climatology of a region can be made without a full knowledge of just such details. Having all this information and by giving a numerical value to the salient phases of each element, increasing as the fire hazard would be increased, by taking the sums or average for all elements a rating number might be assigned each section or subsection, as a coefficient of the fire hazard for that section which would allow of a quick comparison. The details of such a rating will afford interesting material for future conferences between the several fire-weather specialists and the protective agencies.

In the ultimate rating of the fire hazard, however, the human element can not be ignored. Lightning is the major cause of fires only in certain mountain sections. The activities, present or those probable in the future, of the logger, the land clearer, the hunter, fisher, and other vacationists must be considered.